# Mitigation of drought in Southern West-Flanders' aquifers

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**Abstract** This article describes the rate at which groundwater levels in West Flanders are diminishing due to high extraction rates. It evaluates the actions taken by local authorities and describes the founding of 'Centrum Water' as a centre promoting water reuse. This is illustrated with some earlier scientific work on the usage of chlorine dioxide in food industry, with the intention to mitigate the high groundwater demand in West-Flanders.

**Keywords** aquifer; chlorine dioxide; groundwater extraction permit

## INTRODUCTION

The Water Framework Directive (2000/60/EC) defines a good status of groundwater - the goal for 2015 - in terms of both quantity and chemical status. To ensure a stable quantity of groundwater, the directive requires the long-term sustainable use of groundwater. Thus, extraction of water from a groundwater body must not exceed the rate at which freshwater replenishes it.

In Southern West Flanders two important groundwater bodies exist: the 'Landeniaan' aquifer is present at an average depth of 100 meters, the 'Sokkel' aquifer resides much deeper (more than 200 meter average depth). Due to the scarcity of qualitative superficial water, these groundwater sources are extensively used, resulting in dropping groundwater levels. In figures 1 and 2 the dropping groundwater levels in the region are shown.

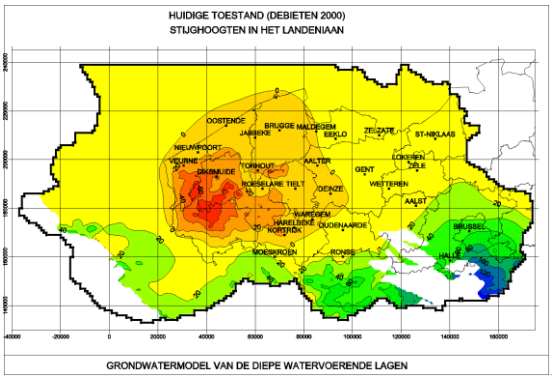


**Figure 1:** groundwater height in the Landeniaan aquifer (1/1/2000).
Source: VMM (Flemish Environmental Agency).

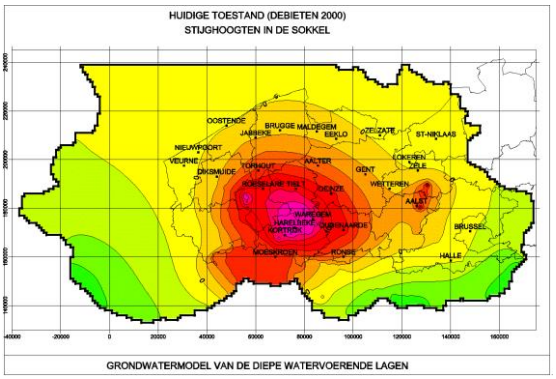


**Figure 2:** groundwater height in the Sokkel aquifer (1/1/2000).
Source: VMM (Flemish Environmental Agency).

The lower groundwater levels are not only a threat to future sustainable exploitation, due to aeration of the aquifers, the quality of the groundwater is deteriorating.

In order to tackle these worsening problems, the Flemish government has decided, based on groundwater modelling prognoses from the division Operational Water management of the Flemish Environmental Agency, to reduce the overall water extraction with 75%. In figures 3 and 4 the different proposed reduction programs and their impact on the groundwater level are shown.

The local authorities (provinces and municipalities) are responsible for the approval of all permits concerning groundwater extraction. This allowed them to gradually reduce the existing permits for groundwater extraction with approximately 25% of the total yearly volume (fig. 5). Despite this achievement, recent data of 1/1/2008 show that there is still a downward trend with respect to most groundwater levels (fig. 6).

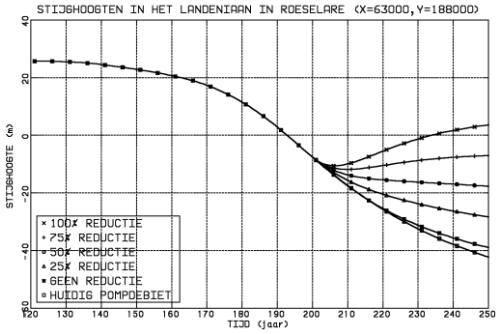


**Figure 3:** modelling of future groundwater levels with different reduction programs for the Landeniaan aquifer. Source: VMM (Flemish Environmental Agency).

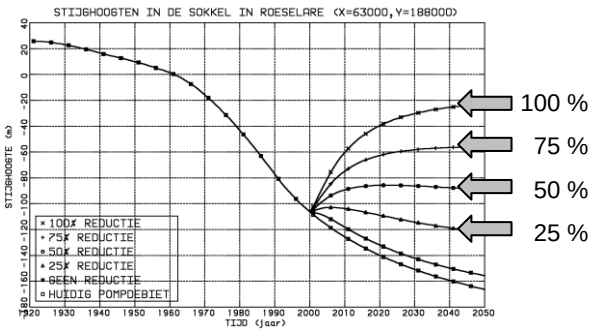


**Figure 4:** modelling of future groundwater levels with different reduction programs for the Sokkel aquifer.
Source: VMM (Flemish Environmental Agency).

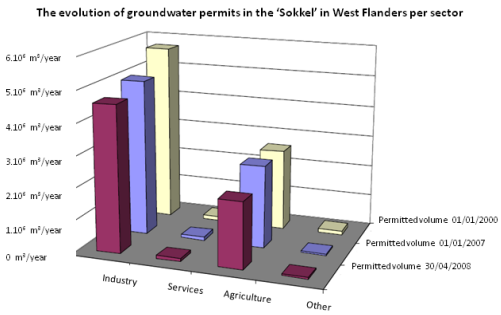


**Figure 5:** the evolution of groundwater permits per sector in the Sokkel aquifer in West Flanders. Source: VMM (Flemish Environmental Agency)

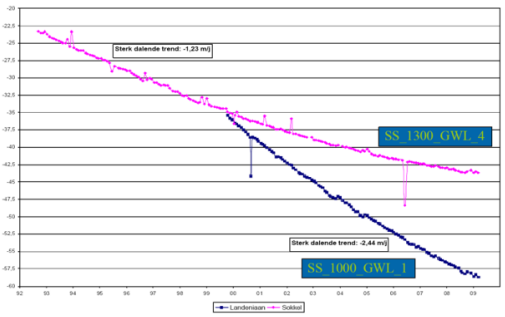


**Figure 6:** an example of diminishing groundwater levels in a well in Diksmuide. 1000: the Landeniaan aquifer, 1300: the Sokkel aquifer. Source: VMM (Flemish Environmental Agency)

In an attempt to promote additional improvements to the groundwater table, Centrum Water offers knowledge support to the local industries and farmers. As such it facilitates companies to meet the stringent criteria of their new permits. To achieve this on a broader base, the centre works on a methodology of water reuse promotion, including on site investigations and pilot scale tests. Several projects have been successfully accomplished in the past as illustrated in the example written below.

Due to permit limitations, the local food industry, a big exploiter of water, is forced to use recycled wastewater, besides groundwater, for the rinsing of vegetables. Microbiological analysis of the water has shown that disinfection is highly desirable. Bleach is relatively cheap and often used, although the use of bleach is discouraged because of the formation of undesired by-products such as trihalomethanes and haloacetic acids. By contrast, chlorine dioxide has strong anti-bacterial properties without the risk of forming hazardous substances. A research project was started to evaluate chlorine dioxide as replacement of bleach and to assess the necessary concentration and contact time for disinfection of washing water.

## METHODS

## RESULTS & DISCUSSION

In figure 7 data from 3 participating companies are shown. With company A en B the effectiveness of $ClO_2$ was tested on recycled effluent of the waste water plant, as well as on captured rainwater. With company C, $ClO_2$ was compared to HOCl (bleach) under equal operational conditions.

| **Sample** | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **Company** | a | b | a | b | c | c |
| **Water type** | effluent | effluent | rain water | rain water | rain water | rain water |
| **COD (mg $O_2$/l)** | 190 | 270 | 81 | 55 | 54 | 54 |
| **Breakpoint (ppm $OCl^-$)** | / | / | / | > 70 | < 10 | < 10 |
| **Disinfectant** | $ClO_2$ | $ClO_2$ | $ClO_2$ | $ClO_2$ | $ClO_2$ | $OCl^-$ |
| **Concentration disinfectant (ppm)** | | | | | | |
| t=0' | 8 | 8 | 8 | 5,5 | 5,4 | 5,4 |
| t=20' | 0,24 | 0 | 0,66 | 0,61 | 3,1 | / |
| **Redox potential** | | | | | | |
| before addition | 299 | 246 | 280 | 295 | 325 | 309 |
| t=0' | 732 | 248 | 720 | 771 | 789 | 415 |
| t=20' | 351 | 229 | 692 | 696 | 751 | 340 |
| **Reduction of microorganisms (log scale)** | | | | | | |
| Total count | 2 | 0,2 | 4 | 2,8 | 4,7 | 3 |
| Coliforms | 1,6 | 0,3 | 3,7 | * | * | * |
| E. coli | / | 0,3 | * | * | * | * |
| Clostridium spp. | 1,3 | 0,25 | 2,7 | * | * | 0 |
| Aerobic spore-forming bacteria | 0,5 | / | 0,5 | / | / | / |

**Figure 7:** results from a measurement campaign with food industry. '/' means no good measurement was registrated. '*' means no reduction was possible because of initial absence of parameter.

Furthermore, during this project it was demonstrated that a more efficient use of $ClO_2$ in the production of blanched vegetables is possible when the integrated blancher- cooler (IBC) is modified to enable non-mixed ice water (5–10 °C) to feed the first row of sprayers. Besides, the addition of $ClO_2$ to the paddle washers for non-blanched vegetables turned out to be ineffective since the $ClO_2$ was immediately consumed by the accumulated organic material.

## CONCLUSIONS

The data show that addition of X mg $ClO_2$/l resulted in a significant lower presence of microbial organisms (4 – 5 log units) if the COD values of the water were not higher than 10*X mg O2/l. For equal concentrations $ClO_2$ gave a better disinfection compared to HClO although the effect of $ClO_2$ on spore forming microorganisms was not significant. $ClO_2$ became ineffective if COD values rose above 100 mg $O_2$/l.


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